

SUBJECT: Astronomy Subsequence in a Multi-Disciplinary Earth Orbital Space Station. Case 720.

DATE: December 27, 1968

FROM: N. Zill

TECHNICAL MEMORANDUM

This memorandum, part of a larger effort to define a multi-disciplinary, earth orbital mission, describes the contributions made and the burdens imposed by a set of astronomy experiments--solar, stellar and planetary. The configuration of the Saturn V B-2 Workshop (Reference 1) was used as an anchor point, but most of what follows has applicability to space laboratories beyond that specific configuration.

I. OBJECTIVES

A. Performance of Astronomical Observations (References 2,3)

These observations aim at taking maximal advantage of the improvements possible in earth orbit, which are:

1. Extension of available spectrum;
2. Increased optical resolution over ~ 1 arcsec limit in earth atmosphere;
3. Elimination of light scattering and airglow;
4. Elimination of weather constraints;
5. Alleviation of geographical and diurnal constraints of fixed earth observatory.

B. Gathering of Technological Data for Future Space Astronomy (Reference 2)

The instrument package outlined below should provide data on:

1. Pointing accuracy in presence of disturbances;
2. Thermal and structural design adequacy to maintain diffraction-limited performance;
3. Degradation of optical surfaces due to high intensity UV, solar wind, and meteoroid environment;

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(NASA-CR-103937) ASTRONOMY SUBSEQUENCE IN A
MULTI-DISCIPLINARY EARTH ORBITAL SPACE
STATION (Bellcomm, Inc.) 11 p

(CATEGORY)

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4. Contaminant build-up on optical surfaces due to proximity to manned spacecraft;
5. Scattering of sunlight due to the halo of particles in vicinity of manned spacecraft;
6. Reliability of astronomical instruments achievable by human maintenance and repair.

II. PHILOSOPHY OF PERFORMANCE - ROLE OF MAN

The astronomy package as here conceived combines basically automatic operation of a stellar-planetary telescope and x-ray and gamma-ray sensors with heavy human involvement in the operation of solar instruments. The reasons for this dichotomy are enumerated below. Let us first list the principal aspects of the astronaut's job in the astronomy subsequence as a whole:

1. Experiment deployment and initiation (including those "repairs" which involve a nudge, bump, kick or push to coax a mechanism into operation).
2. Periodic maintenance and repair (IVA and, to a much more limited extent, EVA) to increase the reliability and life-span of the instruments. Although these functions of the astronaut are not glamorous, their importance, particularly for the complex and expensive astronomy instruments, should not be minimized.
3. Performance of mechanical tasks in which manned execution is still easier and more reliable than automation (e.g., film changing and development).
4. Data selection, editing, and compacting. This function includes not only the elimination of bad data and reduction of "noise," but also the tagging of data highlights: "Something interesting happened here." This aspect of the astronaut's role is economically important in preventing the transmission of billions of bits of useless data and perhaps in alleviating a recurring problem in unmanned scientific programs: the stockpiling of enormous banks of data which will never be utilized by any living information processing system. The astronaut's optimal performance of this role depends on adequate training, sufficient on-line displays to give him, where possible, a multi-sensor look at a given phenomenon and efficient off-line editing facilities. Such displays and editing facilities should be viewed as a requirement on space station experiment and configuration studies.

5. Active control of solar sensors: selection and pointing of instruments at targets on the solar disk. This active control occurs when solar activity justifies it--the performance of routine surveys of a "quiet sun" is done, like the x-ray and gamma-ray surveys, in an automated mode. Similarly, the routine monitoring of the sun for flare births should be as automated as state-of-the-art will permit. This includes preliminary rough pointing of the instruments after the flare alarm has sounded and before the astronaut gets to the console.

The differences in manned participation in solar as opposed to stellar-planetary space station astronomy are due to differences in:

1. Time scale of phenomena. Solar changes of interest occur too rapidly to permit substantial delays between receipt of initial data and control instructions for follow-up data collection.
2. Predictability. Solar feature observations cannot be programmed for months or years in advance as can stellar and planetary positions. Observations of past solar cycles provide guidance as to the probability of occurrence of various features (References 4,5), but the exact locations and times cannot be anticipated.
3. Complexity of pattern recognition and tracking tasks. The complexity of the solar disk, the wide range of interesting features (flares, sunspots, prominences, filaments, streamers, plages, etc.), the need to choose between simultaneously occurring phenomena by criteria which are difficult to program in advance, all demand human participation.

These features of solar astronomy which call for manned operation will also come to apply to planetary space astronomy as that progresses into finer scale (temporal and spatial) study of planetary surfaces. However, for the presently indicated resolving power, an automated, stellar mode is probably sufficient. The on-line displays and editing capabilities do permit more active involvement should it be desirable.

Finally, it should be noted that the technician aspects of the astronaut's role (by no means routine technician, but technician nonetheless) in the astronomy subsequence is somewhat at variance with the training, role perception, and personalities of the current astronaut population.

III. FIRST-ORDER DESCRIPTION OF HARDWARE

A. ATM-B Module (Reference 1)

This consists of a complement of solar telescopes mounted on a spar contained within a thermally-controlled canister, with pointing stability achieved by a fine-gimbal system. Suggested experiments include:

1. Extreme-UV spectroheliograph with refinements in spatial and spectral resolution over ATM-A;
2. UV spectroheliometer and spectrometer;
3. Large-aperture photo-heliograph for high resolution motion pictures of the sun in white light, in the near UV and in H α .

The ATM, together with auxiliary earth-pointing and stellar experiments, is contained within a hangar which can be entered to provide film changing and most repair work in a shirtsleeve environment.* The enclosure is also equipped with hatches to allow EVA inspection and repair, if necessary, and external deployment of auxiliary experiments.

B. EMR Package (Reference 1)

This package involves several telescopes for x-ray and gamma-ray surveys of the sky. The gamma-ray experiments require long observation times with only intermittent astronaut participation. The x-ray platform includes a large-area array (30-100 ft.²) of x-ray proportional counters. Both gamma and x-ray platforms are orientable mounts positioned by the astronaut. Pointing directions can be controlled from the astronaut's console, but the platforms would normally be operated in an automatic survey mode. X-ray and gamma-ray experiments produce data in digital form.

* The hangar configuration is but one possibility. The important feature is the functional capability of performing film changing, maintenance, and repair primarily as IVA.

C. One-Meter Stellar and Planetary Telescope - OAO Module
(References 1,2,6)

This telescope is conceived as a one-meter aperture, Cassegrain telescope with a cavit mirror. It is designed for diffraction-limited performance, but major mission objectives can be obtained even if it does not achieve diffraction-limited performance. A major objective is, in fact, to study the effects of the space environment on a potentially diffraction-limited instrument. For this purpose an automated mirror-inspection system, involving a laser mounted at the radius of curvature of the primary mirror, would be included in the module. This module is designed for operation gimballed to the space station. If attachment to the space station produces problems, the module can be released for unmanned operation.

It should be noted that such a module is only discussed in the maximum payload (C configuration) part of the Saturn V Workshop Study. However, it seems feasible to include this module in an intermediate configuration by taking advantage of the already extensive Grumman technology for the Orbiting Astronomical Observatory (OAO) and the Perkin-Elmer work for the Princeton Advanced Satellite telescope which flies in the OAO (Reference 6). By using support facilities in the space station which are also used by the ATM and EMR units (e.g., film developing equipment), the weight burden on the station from the OAO module can be kept within reasonable limits. Note, however, that there is an important trade-off, not resolved here, between the development of EVA technology and, hence, the amount of EVA permitted for repair, and the configuration complexity and weight penalty necessary to permit non-EVA repair.

The possibility of manned servicing substantially increases the reliability and likely life-span of the complex and costly OAO-Princeton satellite. Likewise, the availability of this module will greatly increase the potential scientific and technological payoff of the space station. The telescope can routinely obtain spectrographic data which is stored on magnetic tape and telemetered to ground. If the diffraction-limited properties of the telescope hold, then a film camera can be installed as well, for high resolution imagery of the planets and stellar objects.

The module concept described above requires the installation in the space station of a simplified OAO command system and data display, including a long-persistence TV display. It also requires development of a docking adapter and fine-gimbal system for the OAO. (Some work in this direction has already been done by Perkin-Elmer, Reference 6.) Nevertheless, it could be considerably simpler than the 1 Meter Telescope Module depicted in the Saturn V Workshop Study (Reference 1).

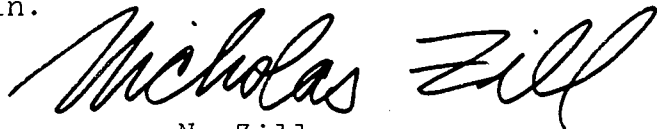
	AVG. POWER (WATTS)	ATT. CONTROL	PRIMARY DATA
ATM-SOLAR	420	± 2.5 sec.	Film, TM
EMR	450	± 15 sec.	TM
STELLAR MODULE	180	$\pm .01$ sec.	TM, Film

IV. ASTRONOMY SUBSEQUENCE MODES

The operation of the astronomy subsequence is detailed in Table I, which presents the various modes, both nominal and contingent, and indicates the function of the crew, mission control, ground-based principal investigators, on-board computer(s), and the astronomy instruments themselves. Estimates of power, information transmission rates, and observation times are derived from current ATM (References 7,8), Princeton satellite-OAO (Reference 6), and Saturn V Workshop (Reference 1) documents but are, of course, only estimates.

ACKNOWLEDGMENT

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N. Zill

1011-NZ-cb

Attachment
Table I

BELLCOMM, INC.

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6. Princeton Advanced Satellite Study, Final Report. Norwalk, Connecticut, Perkin-Elmer, May 15, 1966.
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PROPERTIES	(A) ATM PATROL MODE (NOMINAL)	(B) QUIET SUN MODE (NOMINAL)	(C) ACTIVE SUN MODE (CONTINGENCY)	(D) FLARE MODE (CONTINGENCY)	(E) EMR MODE (NOMINAL)	(F) STELLAR POINT AND CHECK MODE (NOMINAL)	(G) STELLAR OPERATE MODE (NOMINAL)	(H) SAA STANDBY AND SERVICE MODE (NOMINAL)	(I) FILM PROCESSING MODE (NOMINAL)	(J) ASTRON. REPAIR MODE (CONTINGENCY)
I. TIME: a) DURATION, REPETITIONS, USE OF CREW b) CONSTRAINTS	a) 10 ORBITS/DAY UNLESS MORE TIME IS SPENT IN MODES (C) OR (D). NO CREW. b) NONE	a) 6 ORBITS/DAY IN BLOCKS OF 2, UNLESS REDUCED BY TIME SPENT IN (C) OR (D). 1 CREWMAN. b) NIGHT PART OF ORBIT FOR STAND- BY, CHECKOUT, AND SERVICING OF INSTRUMENTS.	a) AT LEAST 6 ORBITS/DAY IN BLOCKS OF 2, WHEN SOLAR ACTIVITY JUSTIFIES, OR UNLESS (D) OVER- RIDES. 2 CREWMEN. b) AVAILABILITY OF CREW. SEE ALSO (B) (I).	a) DEPENDENT ON FLARE ACTIVITY. EXPECTED RATE OF TYPE ≥ 2 FLARES, < 1 PER MISSION DAY. RANGE OF FLARE RISE TIMES (MOST CRITICAL FOR OBSERVA- TIONS) 1-30 MIN. 2 CREWMEN. b) AVAILABILITY AND RAPID ARRIVAL OF CREW. SEE ALSO (B) (I).	a) CONTINUOUS, EXCEPT FOR SAA PASSES, MALFUNCTIONS. NO CREW. b) PARTICLES IN SAA MAY SATURATE X-RAY AND GAMMA-RAY SENSORS, SO THEY MUST BE TURNED OFF DURING SAA PASSES.	a) 5-45 MIN. LONG, DEPENDING ON WHETHER MIRROR INSPECTION IS INCLUDED. ONCE EVERY 2-10 ORBITS, DEPENDING ON OBSERVING PROGRAM. 1 CREWMAN. b) IF POSSIBLE, PERFORM MIRROR INSP. COINCIDENT WITH (H).	a) ESSENTIALLY CONTINUOUS, INTER- RUPTIONS FOR (F), MAINTENANCE AND REPAIR. NO CREW. b) DURING SAA PASSES, PHOTOGRAPHIC WORK SHOULD BE SUSPENDED. SPECTROGRAPHIC MEASURES MAY CONTINUE.	a+b) DURING ORBITS WITH PASSAGE THROUGH THE SOUTH ATLANTIC ANOMALY. EXACT SCHEDULE DEPENDS ON PARAMETERS OF ORBIT (AVG. OF 5 PASSES PER DAY IS REASONABLE). MANPOWER DEPENDS ON PRIOR MODE CONFIGURATION-- H USUALLY REDUCES NEEDED NUMBER OF MEN.	a) THREE HOURS/DAY, USUALLY IN A BLOCK, BUT MAY BE BROKEN, UP, IF NECESSARY. 1 CREWMAN. b) MAY BE POSTPONED OR CANCELLED IF MANPOWER IS REQUIRED FOR (C), (D) OR (J). ADVANTAGEOUS TO SCHEDULE IN CONJUNCTION WITH (H).	a) DURATION, REPETITIONS, AND USE OF CREW ALL CONTINGENT ON SPECIFICS OF MALFUNCTION, BUT ONE MAN USUALLY SUFFICIENT. b) NON-ATM MALFUNCTION SHALL NOT HAVE PRIORITY IN MANPOWER USAGE OVER MODES (C) OR (D).
II. ACTIONS AND FUNCTIONS: AGENTS: MISSION CONTROL CENTER (MCC) CREW ON-BOARD COMPUTER (OBC) PRINCIPAL INVESTIGATORS (PI) (GROUND-BASED) INSTRUMENTS	MCC MONITORS CORRECT OPERATION DURING TM PASSES. AUTOMATIC OPERATION, BUT CREW ON ALERT SHOULD RAPID TRANSI- TION TO MODE D BE NECESSARY. FLARE INDICATORS, BOTH UV CHANNELS, AND ZERO-ORDER DETECTOR OPERATING, CONTROLLED BY OBC. NIL ATM POINTING WITHIN 28 MIN. OF SUN CENTER. LONG UV SPECTRO- METER PERFORMS REPEATING WAVE- LENGTH SCANS (12.5 MINS/SCAN). CHROMOSPHERIC SPECTROGRAPH IN LIMB SCANNING MODE, SPEC- TRAL SEQUENCE.	MCC RELAYS UP-DATES TO CREW, RECEIVES DATA DURING TM PASSES. CREW PERFORMS OBSERVATIONS ACCORDING TO PRE-DETERMINED SCHEDULE. OBC FUNCTIONS IN ASTRONAUT SUPPORT PROGRAM. PI UP-DATES SCHEDULE AS DATA COMES IN. SHORT UV SPECTROHELIO METER IN RASTER SCAN MODE. CHROMO- SPHERIC SPECTROGRAPH IN LIMB SCANNING MODE, SPECTRAL OR MANUAL SEQUENCE. DETERMINE CENTER TO LIMB VARIATIONS, SPHERICAL SYMMETRY, ETC. STEPPED RADIAL OBSERVATIONS FOR PHOTOSPHERE/CHROMOSPHERE TRANSITION.	MCC RECEIVES TM DATA. CREW PERFORMS OBSERVATIONS ACCORDING TO PROGRAM, WITH UPDATES FROM PI, RELAYED BY MCC. ONE CREWMAN IS ACTIVE CONTROLLER OTHER IS EQUIPMENT MONITOR AND COMMUNICATIONS BUFFER. OBC FUNCTIONS IN ASTRONAUT SUPPORT PROGRAM UPDATE PROGRAM SHORT UV SPECTROHELIO METER IN RASTER SCAN MODE. LONG UV SPECTROMETER YOKED TO CHRO- MOSPHERIC SPECTROGRAPH. SPECTROHELIOGRAM MOSAICS, TRACKING OF FEATURES ACROSS DISK AS SUN ROTATES. CHROMO- SPHERIC SPECTROGRAPH IN BORESIGHT MODE, SPECTRAL OR MANUAL SEQUENCE.	MCC RECEIVES TM DATA. BOTH CREWMEN ACTIVELY CONTROL INSTRUMENTS. DATA COLLEC- TION TIME CRITICAL. OBC FUNCTIONS IN ASTRONAUT SUPPORT PROGRAM. PI WATCH FLARE EVENT ON VIDEO LINK THROUGH MCC, WHICH ALSO RELAYS SUGGESTIONS FROM PI TO CREW ON VOICE LINKS. SHORT UV SPECTROHELIO METER IN LINE SCAN MODE. LONG UV SPECTROMETER AS IN (A). HIGH SPEED PHOTOHELIOGRAPHS IN WHITE LIGHT, NEAR UV, AND H α . CHROMOSPHERIC SPECTRO- GRAPH IN BORE-SIGHT MODE, FLARE SEQUENCE.	MCC RECEIVES TM DATA AND TRANSMITS UPDATES. NIL EXCEPT FOR DEPLOYMENT, MAINTENANCE, AND REPAIR, EMR INSTRUMENTS OPERATE AUTOMATICALLY, CON- TROLLED BY OBC. PI REVIEWS TM DATA PERIODICALLY AND UPDATES OBSERVING PROGRAM. X-RAY AND GAMMA-RAY SKY SURVEY.	MCC MONITORS OPERATIONAL DATA TM. CREW CHECKS IMAGE QUALITY, READ- JUSTS FOCUS AND COLLIMATION IF NECESSARY. ONCE A DAY OR LESS, CREW SCANS STELLAR MIRROR WITH LASER SYSTEM. IF FILM CHANGING CAN BE DONE IVA, CREW WILL DO IT AT THIS TIME. OBC FUNCTIONS IN TARGETING PROGRAM, COARSE AND FINE GIMBAL ADJUST. OBC ALSO PROCESSES MIRROR INSPECTION DATA. PI UPDATES OBSERVING PROGRAM ON BASIS OF MIRROR INSPECTION INFO. AND ASTRON. DATA. TELESCOPE IS POINTED TO NEW TARGET (AUTOMATED, CREW MONITORS OPERATION).	RECEIVE TM. NIL OBSERVATION PROGRAM IN OBC CONTROLS TELESCOPE WITH BACKUPS AVAILABLE FROM MCC RADIO CONTROL AND CREW. NIL SPECTROGRAPHIC TM DATA, AND/ OR HIGH RESOLUTION PHOTOGRAPHY OF STARS AND PLANETS.	NIL IF PARTICULAR SENSORS ARE OFF DURING PASSAGE, CREW MAY USE THIS OFF-TIME TO PERFORM ROUTINE MAINTENANCE SERVICE ON THESE INSTRUMENTS. CREW MAY ALSO HAVE TO REMOVE CERTAIN FILM MAGAZINES FROM CAMERAS AND PLACE THEM IN SHIELDED STORAGE. OBC CAN CONTROL SOME OF THE STATUS CHANGES NECESSITATED BY SAA PASSAGE. NIL SENSITIVE FILM AND SOME INSTRUMENTS (SUCH AS X-RAY SENSORS) SHOULD BE PROTECTED FROM PARTICLE RADIA- TION IN SAA. ASTRONOMICAL OBSER- VATIONS MAY CONTINUE BUT IN WAYS DESIGNED TO MINIMIZE RADIATION DEGRADATION.	SEE (2) EXPOSED FILM IS COLLECTED, DEVELOPED, EXAMINED, AND EDITED (DISCARD, CROP, COMPACT, ETC.). ASTRON- OMER ASTRONAUT CONSULTS WITH MCC AND PIs ON DEVELOPMENT TIMES, SUGGESTED EDITING, THEN CARRIES OUT. NIL SEE (2) NIL.	IMPACTED ACTIVITY IS DISCONTINUED OR MODIFIED UNTIL REPAIR IS EFFECTED. UNAFFECTED EXPERIMENTS CONTINUE AS SCHEDULED. SHOULD REPAIRS REQUIRE EVA, THESE REPAIRS MAY BE PERFORMED AS PART OF THE BIOMEDICINE EVA EXPERIMENT PROGRAM.
III. INFORMATION FLOW: a) INFO. REQUIRED b) ACTIVE LINKS c) DATA PRODUCED 1) FILM 2) TAPE 3) REAL-TIME TRANSMISSION	a) INSTRUMENT SYSTEM STATUS. OCCURRENCE OF FLARE BIRTH AND PREDICTED MAGNITUDE OF SAME TO CREW AND MCC. b) ATM-COMPUTER-MCC. COMPUTER- CREW FOR FLARE ALERT. c) 1) PROBABLY < 60 FRAMES PER HOUR OVER ALL CAMERAS. 2) MAX. SUST. 50 KBPS. 3) DUMP (2), FLARE ALERT DATA.	a) DOES ACTIVITY LEVEL OF SUN JUSTIFY GOING TO (C) OR (D)? b) TELEPRINTER: MCC-CREW. c) 1) PROBABLY < 60 FRAMES PER HOUR OVER ALL CAMERAS. 2) MAX. SUST. 50 KBPS. 3) DUMP (2).	a) DISPLAYS FOR TRACKING SOLAR FEATURES. b) VOICE AND TELEPRINTER LINKS: MCC-CREW. c) 1) APPROX. 12 FRAMES PER MIN. FOR EACH OF SEVERAL CAMERAS. 2) TM & OWS, VIDEO $\rightarrow 2 \times 10^4$ KBPS. 3) MAX. SUST. 2×10^4 KBPS.	a) DISPLAY FOR TRACKING FLARE. b) VIDEO TO GROUND. VOICE AND TELEPRINTER LINKS: CREW-MCC-Pis. c) 1) 48 SPECTROGRAMS PER FLARE, OTHER CAMERAS 12-24 FRAMES/ MIN. 2) TM & VIDEO $\rightarrow 2 \times 10^4$ KBPS. 3) VIDEO TO GROUND, PLUS VOICE, TM $\rightarrow$ MAX. SUST. 2×10^4 KBPS.	a) INSTRUMENT SYSTEM STATUS. b) EMR INSTRUMENTS HARDWARE TO COMPUTER. COMPUTER TO MCC. c) 1) NONE. 2) MAX. SUST. 50 KBPS. 3) DUMP (2).	a) VIDEO DISPLAY TO CREW OF TELESCOPE IMAGE. DISPLAYS OF POINTING PARAMETERS AND MIRROR STATUS. b) RADIO CONTROL AND MIRROR DATA LINKS: CREW-TELESCOPE, MCC- TELESCOPE (BACK-UP) c) 1) NONE 2) MIRROR INSP. $\rightarrow$ MAX. SUST. 1 KBPS. 3) DUMP (2).	a) INSTRUMENT SYSTEM STATUS. b) COMPUTER-TELESCOPE, COMPUTER-MCC. c) 1) PROBABLY < 15 FRAMES/HOUR. 2) MAX. SUST. 50 KBPS, SPECTRO- GRAPHIC DATA. 3) DUMP (2), SYSTEM STATUS DATA.	a) MAINTENANCE SCHEDULE FOR INSTRUMENTS. b) NO ADDITIONAL LINKS. c) NO ADDITIONAL DATA.	a) EXPOSURE TIMES, SUBJECTS, FILM TYPES. DEVELOPMENT AND EDITING SUGGESTIONS. b) TELEPRINTER BETWEEN CREW-MCC-Pis. c) DEVELOPED, EDITED PHOTOS FOR RETURN TO GROUND.	a) REPAIR INSTRUCTION, CIRCUIT DIAGRAMS, ETC. b) NONE. c) NONE.
IV. RESOURCES REQUIRED: a) POWER b) OTHER	a) 0.3 KW AVG. b) NONE	a) 0.3 KW AVG. b) NONE	a) 0.5 KW AVG. b) NONE	a) 0.5 KW AVG. b) NONE	a) 0.45 KW AVG. b) NONE	a) 0.20 KW AVG. b) NONE	a) 0.18 KW AVG. (IF OAO SOLAR CELLS ARE NOT USED, .4 KW ADDITIONAL MAY BE REQUIRED). b) NONE.	a) MINIMAL ADDITIONAL POWER, BUT REQUIREMENTS FROM OTHER MODES CONTINUE IN H. b) TOOLS FOR REQUIRED MAINTENANCE AND SPARE PARTS.	a) 0.05 KW FOR DARKROOM AND VIEWING EQUIPMENT. b) DEVELOPING CHEMICALS, LIGHTS, PAPER, ETC.	a) MINIMAL ADDITIONAL POWER. b) TOOLS FOR REPAIR. SPARE PARTS.
V. TRANSITIONS: a) SCHEDULED (NOMINAL) b) UNSCHEDULED (CONTINGENCIES)	a) 1) AT $t_0 + 3, +10-1/2, +18 \rightarrow$ GO TO B. 2) DURING ORBITS WHICH PASS THROUGH SOUTH ATLANTIC ANOMALY (SAA) $\rightarrow$ GO TO H. b) 1) START OF FLARE OF IMPORTANCE 2 OR GREATER $\rightarrow$ GO TO D. 2) MALFUNCTION $\rightarrow$ GO TO J.	a) 1) AT $t_0 + 6, +13-1/2, +21 \rightarrow$ GO TO A. 2) DURING ORBITS WHICH PASS THROUGH SAA $\rightarrow$ GO TO H. b) 1) IF SOLAR ACTIVITY JUSTIFIES, GO TO C. 2) START OF FLARE OF IMPORTANCE 2 OR GREATER $\rightarrow$ GO TO D. 3) MALFUNCTION $\rightarrow$ GO TO J.	a) 1) AT $t_0 + 6, +13-1/2, +21 \rightarrow$ GO TO A, UNLESS UNUSUAL ACTIVITY JUSTIFIES EXTENSION. 2) DURING ORBITS WHICH PASS THROUGH SAA $\rightarrow$ GO TO H. b) 1) START OF FLARE OF IMPORTANCE 2 OR GREATER $\rightarrow$ GO TO D. 2) MALFUNCTION $\rightarrow$ GO TO J.	a) 1) DURING ORBITS WHICH PASS THROUGH SAA $\rightarrow$ GO TO H. b) 1) UPON COMPLETION OF FLARE OBSERVATIONS $\rightarrow$ GO TO A, B, C, I, WHICHEVER APPROPRI- ATE. 2) MALFUNCTION $\rightarrow$ GO TO J.	a) 1) DURING ORBITS WHICH PASS THROUGH SAA $\rightarrow$ GO TO H. b) 1) MALFUNCTION $\rightarrow$ GO TO J.	a-1) AT END OF POINT AND CHECK OPERATIONS $\rightarrow$ GO TO G. b-1) MALFUNCTION $\rightarrow$ GO TO J.	a-1) WHEN OBSERVING PROGRAM INDICATES $\rightarrow$ GO TO F. a-2) DURING SAA PASSES $\rightarrow$ GO TO H (SEE ABOVE). b-1) MALFUNCTION $\rightarrow$ GO TO J.	a-1) WHEN SAA PASSAGE IS OVER, RETURN TO UNMODIFIED PRIOR MODES. b-1) MALFUNCTION $\rightarrow$ GO TO J.	a-1) AT END OF THREE HOURS GO TO APPROPRIATE OTHER MODES. b-1) START OF FLARE OF IMPORTANCE 2 OR GREATER $\rightarrow$ GO TO D. b-2) MALFUNCTION $\rightarrow$ GO TO J.	b-1) WHEN REPAIR IS COMPLETED, RETURN TO APPROPRIATE SCHEDULED MODE CONFIGURATION. b-2) START OF FLARE OF IMPORTANCE 2 OR GREATER $\rightarrow$ GO TO D (IF MANPOWER IS NEEDED).

TABLE I ASTRONOMY SUBSEQUENCE

BELLCOMM, INC.

COVER SHEET FOR TECHNICAL MEMORANDUM

TITLE - Astronomy Subsequence in a Multi-Disciplinary Earth Orbital Space Station.

TM-68-1011-5

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DATE - December 27, 1968

AUTHOR(S) - N. Zill

FILING SUBJECT(S) -
(ASSIGNED BY AUTHOR(S) -

Mission Planning
Manned Space Station
Astronomy

ABSTRACT

A set of astronomy experiments for an intermediate configuration multi-disciplinary, space laboratory is described and the in-orbit operation of these experiments is presented with estimates of time, crew, information flow, and power requirements.

The astronomy package as here conceived aims at taking maximal advantage of the observational improvements possible in earth orbit over ground-based instruments, and, at the same time, gathering technological data for future space astronomy. The package combines basically automatic operation of a one-meter stellar-planetary telescope and x-ray and gamma-ray sensors with extensive human participation in the operation of ATM-derived solar instruments.

The astronaut's role is comprised of:

1. Experiment deployment and initiation.
2. Periodic maintenance and repair.
3. Performance of certain mechanical tasks.
4. Data selection, editing, and compacting.
5. Active control of solar sensors, which is necessitated by the time scale rapidity, positional unpredictability, and pattern-recognition complexity of solar features.

BA-145A (7-65)

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